

What is claimed is:

1. A method, comprising:
  - 5 performing vapor deposition with an organometallic vapor including copper to form a number of nanostructures on a substrate, the nanostructures each being freestanding during formation and composed of a material including copper; and wherein said performing provides the nanostructures each with a first dimension of 500 nanometers or less and a second dimension extending to a respective free end of at least ten times the first dimension.
- 10 2. The method of claim 1, wherein the nanostructures are each monocrystalline.
3. The method of claim 1, wherein the nanostructures are each in the form of nanowires with the second dimension being at least 50 times greater than the first dimension, and the nanostructures essentially consist of copper.
- 15 4. The method of claim 1, wherein the organometallic vapor includes  $\text{Cu}(\text{ethylacetoacetate})\text{L}_2$  with L being trialkyl phosphite.
- 20 5. The method of claim 1, which includes enclosing the substrate and the vapor in a chamber and generating the vapor by evaporating a copper-containing precursor.

6. The method of claim 5, which includes heating the substrate to no more than about 400 degrees Celsius during said forming.
7. The method of claim 5, which includes providing oxygen during the vapor  
5 deposition so that the material includes an oxide of copper.
8. The method of claim 5, wherein the vapor deposition is of a chemical vapor deposition type.
- 10 9. A method, comprising:  
depositing a number of monocrystalline nanowires on a substrate from an organometallic substance, the nanowires each being freestanding during deposition and composed of a material including a metal; and  
providing the nanowires with a first dimension of 500 nanometers or less after the  
15 deposition is completed.
10. The method of claim 9, which includes incorporating one or more of the nanowires into at least one of an integrated circuit device, a device to process signals having a frequency of 100 GHz or more, a display device, and a sensing device.  
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11. The method of claim 9, wherein the metal is copper and the material essentially consists of copper.

12. The method of claim 9, wherein the organometallic substance includes Cu(ethylacetoacetate)L<sub>2</sub> with L being triakyl phosphite.

13. The method of claim 9, wherein said depositing includes performing a chemical vapor deposition with the organometallic substance and heating the substrate during said performing to a temperature of no more than about 400 degrees Celsius.

14. The method of claim 9, wherein the first dimension of each of the nanowires is 50 nanometers or less.

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15. A method, comprising:

noncatalytically forming a nanowire on a substrate by performing vapor deposition with an organometallic substance;

growing the nanowire during said forming in a direction away from the substrate,

15 the nanowire being freestanding during said growing; and

wherein the nanowire has a first dimension of 500 nanometers or less and a second dimension extending from the substrate to a free end of the nanowire at least 10 times greater than the first dimension.

20 16. The method of claim 15, wherein the nanowire is one of a plurality of nanowires made on the substrate during said forming and each of the nanowires has a diameter of 50 nanometers or less.

17. The method of claim 15, wherein the nanowire is monocrystalline.

18. The method of claim 15, wherein the nanowire essentially consists of copper or an oxide of copper.

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19. The method of claim 15, wherein the organometallic substance includes Cu(ethylacetoacetate)L<sub>2</sub> with L being trialkyl phosphite.

20. The method of claim 15, wherein the vapor deposition is of a chemical vapor  
10 deposition type and said forming includes enclosing the substrate in a chamber and heating the substrate to a temperature of 400 degrees Celsius or less during the vapor deposition.

21. A method, comprising:  
15 growing a number of monocrystalline nanowires on a substrate from an organometallic substance including copper, the nanowires each being composed of a material including copper; and  
providing the nanowires with a first dimension of 500 nanometers or less after said growing is completed.

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22. The method of claim 21, which includes incorporating one or more of the nanowires into at least one of an integrated circuit device, a device to process signals with a frequency of 100 GHz or more, a display device, and a sensing device.

23. The method of claim 21, wherein the organometallic substance includes

$\text{Cu}(\text{R}^1\text{OCOCR}^2\text{COR}^3)\text{L}_x$ , wherein:

$\text{R}^1$  is a  $\text{C}_1\text{-C}_9$  hydrocarbyl group;

$\text{R}^2$  is H, fluorine F, or a  $\text{C}_1\text{-C}_9$  hydrocarbyl group;

5  $\text{R}^3$  is a  $\text{C}_1\text{-C}_9$  hydrocarbyl group or an alkylsilane group of the formula  $\{-\text{Si}(\text{R}^4)(\text{R}^5)(\text{R}^6)\}$ , in which  $\text{R}^4$ ,  $\text{R}^5$ , and  $\text{R}^6$  are each H, F, a  $\text{C}_1\text{-C}_9$  hydrocarbyl group, or a  $\text{C}_1\text{-C}_9$  alkoxy group of the formula  $\{-\text{OR}\}$ , in which R is a  $\text{C}_1\text{-C}_9$  hydrocarbyl group bonded to silicon (Si);

x is 1, 2, or 3; and

10 L is a ligand of the formula  $\{\text{P}(\text{R}^7)(\text{R}^8)(\text{R}^9)\}$ , in which  $\text{R}^7$ ,  $\text{R}^8$ , and  $\text{R}^9$  are each a hydroxy group, a  $\text{C}_1\text{-C}_9$  hydrocarbyl group, or an alkoxy group of the formula  $\{-\text{OR}\}$ , in which R is a  $\text{C}_1\text{-C}_9$  hydrocarbyl group.

24. The method of claim 23, which includes performing chemical vapor deposition

15 with the substrate at a temperature of 400 degrees Celsius or less and a pressure of 1.0 torr or less during said growing.

25. The method of claim 24, wherein said performing includes decomposing a vapor to release at least a portion of the copper included in the copper of the nanowires.

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26. The method of claim 21, wherein the first dimension of each of the nanowires is 50 nanometers or less and the material essentially consists of copper or an oxide of copper.

27. The method of claim 21, which includes incorporating the nanowires into at least one of an integrated circuit device, a device to process signals having a frequency of 100 GHz or more, a display device, and a sensing device.

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28. An apparatus, comprising:

a substrate;

a plurality of freestanding nanowires attached to the substrate, the nanowires each being monocrystalline and including copper; and

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wherein the nanowires each include a respective free end, each have a first dimension of 500 nanometers or less, and each have a second dimension extending from the substrate to the respective free end, the second dimension being at least 10 times greater than the first dimension.

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29. The apparatus of claim 28, wherein the nanowires contact a substrate surface comprised of at least one of a semiconductor, a dielectric, and a metal.

30. The apparatus of claim 28, wherein the substrate is comprised of silicon dioxide.

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31. The apparatus of claim 28, wherein the nanowires consist essentially of copper.

32. The apparatus of claim 28, wherein the nanowires include an oxide of copper.

33. The apparatus of claim 28, wherein the first dimension is less than 10 nanometers.

34. The apparatus of claim 28, wherein the second dimension is at least 50 times the first dimension.

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35. The apparatus of claim 28, wherein the substrate includes a semiconductor surface and the nanowires contact the semiconductor surface.

36. The apparatus of claim 28, wherein the substrate includes a metallic surface and  
10 the nanowires contact the metallic surface.

37. An apparatus, comprising:  
a substrate with a dielectric surface;  
a plurality of freestanding nanowires in contact with the dielectric surface of the  
15 substrate, the nanowires each including copper; and  
wherein the nanowires each include a respective free end, each have a first  
dimension of 500 nanometers or less, and each have a second dimension extending from  
the substrate to the respective free end, the second dimension being at least 10 times  
greater than the first dimension.

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38. The apparatus of claim 37, wherein the substrate is comprised of silicon dioxide.

39. The apparatus of claim 37, wherein the nanowires consist essentially of copper.

40. The apparatus of claim 37, wherein the first dimension is 50 nanometers or less.